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ABSTRACT

This study was conducted to compare effects of concept mapping and conceptual change texts instruction over traditional instruction on 10th grade students' understanding of acid and base concepts. 110 students from 6 classes of a chemistry course taught by the same teacher were enrolled in the study. There were four experimental group classes and two control group classes. Two experimental groups class were instructed with concept mapping instruction; and the other two experimental groups were taught with conceptual change texts instruction and the next two classes were assigned as control group students instructed with traditional instruction. All students were administered the Acids and Bases Concept pre-test and post-test. A two-way ANOVA was used for statistical analyses. The results showed that concept mapping instruction and the conceptual change texts instruction caused a significantly better acquisition of scientific conceptions related to acids and bases than the traditional instruction. Also, there was no effect of gender difference on understanding of acid and base concepts. (Contains 37 references.) (Author/MM)

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CONTRIBUTION OF CONCEPTUAL CHANGE TEXTS AND CONCEPT MAPPING TO STUDENTS' UNDERSTANDING OF ACIDS AND BASES

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Abstract

This study was conducted to compare effects of concept mapping and conceptual change texts instruction over traditional instruction on 10th grade students' understanding of acids and bases concept. 110 students from six classes of a chemistry course taught by the same teacher were enrolled in the study. There were four experimental group classes and two control group classes. Two experimental groups class were instructed with concept mapping instruction: and other two experimental group were taught with conceptual change texts instruction and next two classes assigned as control group students instructed with traditional instruction. All students were administered Acids and Bases Concept pre-test and post-test. Two-way ANOVA was used for statistical analyses. The results showed that concept mapping instruction and the conceptual change texts instruction caused a significantly better acquisition of scientific conceptions related to acids and bases than the traditional instruction. Also, there was no effect of gender difference on understanding of acids and bases concepts.

Keywords: Misconception, Conceptual Change Approach, Conceptual Change Texts, Concept Mapping, Acids and Bases.

Introduction

It has been widely accepted that learning is the result of interaction between what students are taught and their current ideas and concepts. Cognitive structure of the learner determines his learning process. The most important single factor influencing learning is what the learner already knows (Ausubel, 1968). During instruction, learners generate their own meaning based on their background, attitudes, abilities and experiences. Learners develop a set of well-defined ideas about natural objects and events even before coming to classroom. Often these ideas conflict with accepted scientific explanations. Difficulties arise when students' ideas differ from the definition accepted by scientists (Osborne & Wittrock, 1983). These different ideas are referred as misconceptions (Cho, Kahle & Nordland, 1985; Griffiths & Grant, 1985). Misconceptions are defined as students' conceptual and prepositional knowledge, which is inconsistent with or different from the commonly accepted scientific consensus. They have been given several names including alternative frameworks (Driver & Erickson, 1983), naive beliefs (Caramazza, McCloskey & Green, 1981), preconceptions (Hashweh, 1988), children's science (Gilbert, Osborn & Fensham, 1982), naive theories (Resnick, 1983), intuitive beliefs (McClosky, 1983), intuitive science (Preece, 1984), learner's science (Wittrock, 1985).

Over the past 20 years, interest in students' misconceptions with regards to chemistry has increased. Most of the work dealing with students' misunderstandings, learning difficulties, and misconceptions in chemistry has been focused on relatively limited amount of topics, such as the mole concept (Duncan & Johnstone, 1973; Novik & Manis, 1976), entropy (Campbell, 1980; Frazer, 1980), chemical equilibrium (Camacho & Good, 1989; Gussarsky & Gorodetsky, 1990), covalent bonding (Peterson and Treagust, 1989), electrochemistry (Garnett & Treagust, 1990).

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Many of these topics about which students hold misconceptions are basic to chemistry knowledge and interrelated. Although beginning students are often confused by concepts of acid-base chemistry (Treptow, 1986), studies that focus specifically on acids and bases are not many.

Zoller (1990) examined the college students' misconceptions. Freshman nonmajors get confused in understanding the Lewis generalization that combines acidity, basicity, electrophilicity, and nucleophilicity within a broad integrated scheme. Moreover, most students could not internalize the pH concept. Similar results were found by Schmidt (1991). In his study, it was identified that in any neutralization reaction a neutral solution is formed, even if weak acid or base takes part in the reaction. Banerjee (1991) developed and administered a written test to diagnose misconceptions in chemical equilibrium including gaseous, ionic, solubility, and acid-base equilibrium among undergraduate chemistry students and school teachers of chemistry. He concluded that students had misconceptions that rainwater is neutral; for the same concentration the pH of acetic acid will be less than or equal to that of hydrochloric acid solution in water, and there are no hydrogen ions in an aqueous solution of sodium hydroxide or in distilled water. Bradley and Mosimege (1998) investigated whether student teachers at a university and a college of education hold any misconceptions about acids and bases. They found the following misconceptions: Aqueous solutions of all salts are neutral; there are misconceptions regarding conjugate bases, an indicator is paper used in laboratory when testing whether the acid is strong or weak; indicator neutralizes the acidity property of a solution to a more basic one.

Ross and Munby (1991) investigated senior high-school students' understandings of concepts related to acids and bases. The following misconceptions

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were found: All acids are strong and powerful; acidic substances are not to be ingested; substances that burn are acids; acids contain hydroxide ions; all acids are poisonous; fruits are basic; a gas is produced during the neutralization of hydrochloric acid by potassium hydroxide; hydrogen is displaced from an acid when it mixed with magnesium; more hydrogen gas is displaced from a strong acid because the strong acid contains more hydrogen bonds than a weak acid; acids taste bitter and peppery; all substances with sharp or strong smells are acids. Hand and Treagust (1991) revealed that there are common misconceptions that an acid is something which eats material away; an acid can burn you; testing of an acid can only be done by trying to eat something away; to neutralize is to break down an acid or to change from an acid; a base is something which makes up an acid; and a strong acid can eat material away faster that a weak acid. Nakhleh and Krajcik (1994) investigated changes in secondary students' understanding of acid, base, and pH concepts. The interviews showed that the students were unable to fully understand the acid-base chemistry because they tended to have work understanding of the particulate model of matter and of how that model relates to some of chemistry's classification systems, such as molecules, atoms, and ions.

In high school chemistry curricula, the topic of acids and bases occupies a central place. This unit has important role in understanding other chemistry topics, such as, chemical reactions and acid base equilibrium. In addition, commercial application of acid-base and public awareness over environmental issues make acid base unit essential in chemistry as a school subject. Therefore, while learning acid-base concept, teachers should instruct students with the methods that encourage conceptual change.

The many empirical studies provide ample evidence that students hold pre-instructional conceptions in many fields and that these are substantially different from the scientific concepts taught in schools. Most of these conceptions are held strongly and hence are very resistant to change. Since new knowledge is linked to existing conceptions, misconceptions interfere with further learning. Students' ideas often interact with knowledge presented in formal science lessons resulting in unintended learning outcomes.

Learning science in a meaningful way involves realizing, reorganizing or replacing existing conceptions to accommodate new ideas (Smith and Blakesie, 1993). Various instructional methods can be used for this purpose. Posner, Strike, Hewson and Gertzog (1982) proposed four conditions for conceptual change. If students are to change their ideas, they must become dissatisfied with existing misconceptions (dissatisfaction), new concept or ideas must provide a better explanation and be understandable (intelligibity), these new concepts must appear to propose solutions to problems and must be in accordance with knowledge matter in other areas and be believable (plausibility), and they must lead to new insights and have potential for new discoveries (fruitfulness). Conceptual change approaches are effective in science learning (Gunston and Northfield, 1992; Hewson and Hewson, 1988; Chambers and Andre, 1997; Hynd, McHorter, Phares and Suttles, 1994).

One of the conceptual change strategies involves the use of conceptual change texts. The conceptual change text strategy is designed according to a model of conceptual change to overcome misconceptions. Wang and Andre (1991) created a conceptual change text by adapting traditional science texts about electricity. They found that the conceptual change text facilitated conceptual understanding of circuits. They did note that while conceptual change text was facilitative for both males and

females, it was facilitative for males when the instructional texts were more demanding. This strategy was also employed by Hynd et. al. (1994), and use of a conceptual change text was effective in creating conceptual conflict and meaningful learning in students about Newton's law of motion. In this study, conceptual change texts were used to lead better understanding of acid-base concepts.

Concept mapping, another conceptual change strategy, best displays the intricate and complex relations among the concepts of acid, base and PH that are involved in an understanding of acid-base chemistry. These concepts are also intertwined with other major concepts of chemistry and a concept map provides a clear representation of students' understanding of the way in which concepts are interrelated. Concept maps also indicate gaps in these interrelations as well as weak understandings. A sense of magnitude and direction of the charge could also be obtained by scoring the maps gain scores from initial to final maps for each student and by comparing the average gain scores across technology groups (Nakhleh and Krajcik, 1994). Concept maps for instruction are developed by listing relevant concepts and then drawing lines between them to represent important interrelationships (Ross & Munby, 1991). They are used for teaching and learning as well as for research. Among its many uses, concept maps allow for evaluation of prior knowledge and diagnosis of alternative conceptions. Further, the concept map serves as a device to illustrate the hierarchical, conceptual and prepositional nature of knowledge. In this study, concept mapping was used to cause meaningful learning in acid-base concepts.

Method

Problem

The aim of this study was to investigate effectiveness of concept mapping and conceptual change texts strategy over traditional instruction method on students' understanding of acids and bases concepts. In addition, the effect of gender difference on understanding of acids and bases concepts was examined.

Subjects of the Study

110 10th grade high school students (47 female, and 63 male) from six chemistry classes were enrolled in this study. There were four experimental and two control groups: two of the experimental groups was exposed to concept mapping instruction and the other two experimental group were taught with conceptual change texts oriented instruction and the next two classes assigned as control groups which were exposed to traditional instruction.

Instruments

Acids and Bases Concept Test (ABCT)

A concept test developed by the researchers was administered to experimental and control group students in order to compare the students' understanding of acids and bases concepts. ABCT consisted of 25 multiple-choice questions. Each question had one correct answer and three distracters.

As developing concept test, initially instructional objectives about acid-base chemistry were stated. Then, literature related to students' misconceptions with respect to acids and bases was examined and individual interviews with ten students of the 11th graders were performed to examine students' misconceptions on acid-base chemistry. Misconceptions gathered from interviews and related literatures were reflected by the distracters of each test items. Table 1 summarizes the common

misconceptions in acids and bases. Final form of the test was constructed following the pilot study. The reliability (Cronbach's alpha) of the test was found to be 0.78.

Table 1. Common Students' Misconceptions in Acids and Bases

Misconceptions
1. A gas is produced during the neutralization of HCl acid and NaOH base.
2. More hydrogen gas is displaced from a strong acid because the strong acid contains more hydrogen bonds than a weak acid.
3. Acids taste bitter and peppery.
4. All substances with sharp or strong smells are acids.
5. Acidic substances are not be ingested.
6. Substances that burn are acids.
7. All acids are poisonous.
8. Fruits are basic.
9. Soil can not be acidic because things grow in it.
10. Strong acids have a higher pH than do weak acids.
11. Neutralization always results in a neutral solution.
12. Because a salt contains neither hydrogen nor a hydroxyl group, its solution can not contain hydronium nor hydroxide.
13. Electrolysis and hydrolysis are the same.
14. All salts can be hydrolyzed.
15. All acids or bases conduct electricity same.
16. The strength of an acid depends on the number of hydrogen atoms in an acid.
17. The solubility in water of an acid or base depends on the conduction of electricity.
18. Substances containing H are acidic; substances containing OH are basic.
19. When a proton donor acid reacts, the nucleus of an atom loses a proton.
20. All acids and bases ionize completely.

Treatment

This study was conducted over a 5-week period. In the study, there were six groups of students: four experimental groups and two control groups, instructed by the same teacher. The teacher has six years experience in teaching chemistry and had masters' degree in science education program. The topics related to acid-base chemistry were covered as part of the regular classroom curriculum in the chemistry course. These topics were definition of acids and bases, properties of acids and bases, strength of acids and bases, pH concept, neutralization and hydrolysis. All six groups of students studied the same topics. The two experimental groups were instructed by the concept mapping instruction. Before treatment, the students in concept mapping instruction groups were trained about development and implementation of concept mapping. Then, the teacher gave lecture about acids and bases by emphasizing the links among concepts of acids and bases. Meanwhile, she encouraged students to create relationships among concepts through discussion and questioning. After teaching all concepts, students were asked to construct their own maps. During this time, the teacher helped students having difficulty in finding relationships among concepts. She gave students simple clues and reminded the related parts of lecture. After students constructed their own concept maps, maps prepared by the researchers were distributed to all students in these groups. By this way students have opportunity to see the differences between their maps and the researchers' maps.

In the next two experimental groups, conceptual change texts instruction group, conceptual change texts were distributed to students after presenting each concept. Students were asked to read texts carefully. Conceptual change texts were designed for explaining students' misconceptions, causes of these misconceptions, why these conceptions were incorrect; and informing students about scientifically

correct explanation. In these groups process appropriate for conceptual change approaches was followed. Initially, questions were asked. In this way, students' current conceptions were expected to be activated about subject matter and waited for responding the question. Then conceptual change texts provided plausible and fruitful knowledge and examples concerning the correct concept. So that students had opportunity to develop scientifically accepted conceptions. For example, one of texts was related to properties of acids and bases. Students were informed about the fact that some of the acids are edible. In order to activate previous knowledge of the students and cause dissatisfaction with their current conceptions, they were asked whether edible substances contains acidic properties. Next, students were expected to answer to this question individually. Then, the misconception that "all acids are poisonous" was presented as a belief that some students have. And then, conceptual change text explained that some of the acidic substances are not poisonous. In order to clarify the explanation about misconception in text, some of the edible substances were given as examples of substances containing acids, such as, apple, lemon, vinegar, and tomatoes. As a result, this text helped students realize that not all acids are poisonous, and even there are acidic substances in our diet.

In the control groups, the students were instructed with traditional instruction. During the classroom instruction, the teacher used lecture and discussion methods and solved algorithmic problems to teach acids and bases concepts without considering students' misconceptions. Students read their textbook on their own. The instruction was teacher centered. The teacher explained each concept and asked questions by directing students' answers. Also, the students were provided with the worksheets. Each worksheet included mathematical and conceptual chemistry questions.

Worksheets were corrected and scored and the students reviewed their responses after correction.

Results

In order to identify students' prior knowledge in acids and bases chemistry, Acids and Bases Concept Test was administered to all groups before treatment. The results showed that there was no significant mean difference among groups ($p>0.05$).

After treatment, two-way ANOVA was run to compare the effects of three types of instruction (conceptual change texts instruction, concept mapping instruction and traditional instruction) and to see effect of gender difference on students' understanding of acids and bases concepts. The result indicated that there was a significant difference among three groups with respect to students' understanding in acids and bases concepts ($p<0.05$). However, there was no significant mean difference between male and female students in terms of understanding of acid and bases concepts ($p>0.05$).

In order to determine which group causes the significant difference, post-hoc analysis was performed. This analysis showed that there was a significant mean difference between traditional instruction groups and the concept mapping instruction groups. The concept mapping instruction groups showed higher performance than the traditional instruction groups in terms of understanding measured by concept test. Also, a significant difference was found between conceptual change texts instruction groups and traditional instruction groups in favor of the conceptual change texts instruction groups.

Discussion

The results indicated that the concept mapping instruction and the conceptual change texts oriented instruction produced significantly greater achievement in acids

and bases concepts than traditional chemistry instruction. In traditional instruction, the teacher didn't consider students' existing ideas and misconceptions. She stressed lecture method, used textbook to transfer knowledge. Also, when needed, she encouraged students for teacher-guided discussions. In contrast, in experimental groups, the teacher dealt with students' current knowledge and misconceptions. Based on students' ideas, she planned the flow of the course. This study showed the similar results with the studies conducted for examining the effectiveness of concept mapping and conceptual change text oriented instruction (Okebukola, 1990; Horton et al., 1993, Hydn et al.,1994)). From this result, it can be concluded that concept mapping instruction is one of the effective teaching strategies in order to dispel students misconceptions. In concept mapping instruction groups, students prepared their own concept maps on the related concepts. This allowed students to think in multiple directions (Okebukola, 1990), to externalize all the relationships formed in their cognitive structure, and to learn the acids and bases concepts meaningfully. However, students in the control groups were not exposed to instructional methods that would help them realize the presence of certain misconceptions present in their minds and overcome these misconceptions. In the concept mapping instruction groups, the teacher emphasized students' misconceptions during presentation of topics and made them dissatisfied with their existing knowledge by asking questions. Then, they accepted scientific explanation of the concepts. Students involved in activities that helped them acquire meaningful learning by making relationships among concepts. While they were constructing their maps, the teacher helped students having difficulty. In this way, teacher-student interaction was enhanced. All students participated in learning process actively, expressed their ideas and thought critically. On the other hand, students using conceptual change texts were involved in activities

that helped them revise their prior knowledge and struggle with their misconceptions. For example, in the conceptual change texts, emphasis was given to students' misconceptions. In order to deal with these misconceptions, which let them accept better explanations to the problems that were introduced. In this way, students were allowed to think about their prior knowledge and reflect on it.

The reason why the students in the control groups were unsuccessful may be due to the fact that traditional instruction didn't provide learning environment to compare their existing concepts with new ones. According to Ausubel (1968) students' existing concepts have great influence on their further learning. Also, Hewson and Hewson (1988) claimed that students' prior knowledge might cause difficulties during learning process. In short, students in the control groups didn't realize their misconceptions and connected new information to their existing cognitive structure wrongly.

The results of the study have some implications for science educators. Since concept mapping and conceptual change texts are effective strategies for dispelling students' misconceptions, curriculum designer should consider these strategies in developing science curriculum So that, students are encouraged to carefully examine their own conceptions during instruction. In addition, science teachers could have chance to activate students' common misconceptions and help them change their already existing misconceptions. In short, a well-designed conceptual change approach in science instruction should be integrated in to school system for removing misconceptions and enhancing meaningful learning.

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